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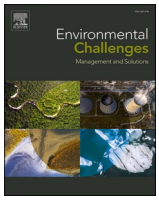

Assessing the Advantages of Tissue Culture Bananas Technology Production of Banana Farmers in Kisii County, Kenya

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ABSTRACT

Over the years, governments from all over the world have attempted to attain food security, albeit with varying degrees of success. To feed the expanding population, agriculture has significantly increased in intensity. One of the technologies employed is banana tissue culture. Most research studies indicate that small-scale farmers in Kisii County have not adopted this technology at high rates, despite efforts to spread its use among them. The objective of the study was to examine the how advantages of tissue culture banana adoption influence the use of tissue culture banana technology in Kisii County. The study adopted a descriptive study approach. A simple random sampling procedure was used to choose the respondents. Survey forms, interview schedules, and observation checklists were used in the data collection process. A five-Likert scale study was employed to gather farmers' advantages of Tissue Culture bananas. The associations between tissue culture banana adoption and advantages were displayed using mean comparison procedures. Non-adopters' inadequacy of awareness of advantages about adopting bananas from tissue culture was proven to have a major impact on the practice. Compared to adopters, whose average mean was determined to be 1.28, non-adopters' average mean was 2.494. Comparing adopters of tissue culture banana technology to non-adopters in Kisii County, this suggests that the former had a better grasp of the advantages in tissue culture banana production. Consequently, there is a need to raise farmers' understanding of the general challenges surrounding technology in the area in order to improve on the technology adoption.

Introduction

Food availability and distribution are not limited by time or geography, even though there may be enough food in the world to feed everyone. The average person's daily nutritional requirement for energy is 2881 kcal, while only 2353 kcal are provided by conventional diets worldwide (FAO, 2014). Food shortages in a region can be regularly caused by a variety of factors, including unfavorable conditions for food production, environmental degradation, labor or supply chain disruptions due to extreme weather, economic crises, conflicts or insecurity, sanctions, and health shocks like epidemics. These factors could have an impact at both the macro and micro levels (Crises, 2021). This begs the question of what would happen if food production plummeted, food supplies were drastically curtailed, or international trade declined as a result of increased protectionist policies. Although such a scenario is rare, it might have a major effect on the food supply in nations that import food and exacerbate the situation in nations where there are already acute food shortages (Udmale et al., 2020). One of the key elements of food balance is international trade as part of supply chains or distribution; if this is disturbed by a global shock, it may have long-lasting detrimental effects on food security (FAO, 2017)

Today, hunger is the world's most pressing problem (FAO, 2014) whereby approximately 98 million Africans—or more than 20 percent of the 840 million hungry people worldwide—experience hunger. In many Sub-Saharan African (SSA) countries, where a sizeable labor force is employed in agriculture, agriculture is the main source of income for rural population (Panel et al., 2011), Over 10 million Kenyans, or about 25 % of the population, do not always have access to enough food in appropriate quantities or of suitable quality, hence they mostly rely on food aid (Sibhatu et al., 2015). The Sustainable Development Goals state that Kenya and other Sub-Saharan African countries must implement the required agricultural reforms in order to solve the issues of hunger and

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poverty and keep up with the world's expanding population (Kentikelenis et al., 2016). This implies that emerging nations with rapid population expansion, such as Kenya, could not be able to meet their food demands in comparison to developed nations if a solution is not found (Fischer and Qaim, 2012). It will be crucial to raise food production in proportion to population increase in order to provide the many undernourished people living in developing countries with a nutritious diet (Joosten et al., 2015). Agricultural technology as it exists today will not be able to address the issue of future production, necessitating the creation of new plans to boost food production. Analysts lament that widely adopted green revolution technologies no longer provide breakthroughs in yield potential or solutions for difficult insect, disease, and drought stress problems (Karembu et al., 2010).

The banana, a plant in the *Musaceae* family, supplies more than 25 % of the daily carbohydrate needs for people on Earth (Njue, 2015). Over 150 countries planted banana trees in 2017, resulting in 113.91 million tons of production worldwide (FAOSTAT 2018). According to a surveys, India is the world's top producer of bananas, contributing more than 25% of worldwide production annually, or more than 30.47 million tons (Banana Tissue Culture in India, 2019). FAO (2018) mentioned that with 5.1 million tons overall, Cameroon was leading the way in Africa. Comparing Kenya's banana production to the 40–50 tons/ha needed internationally, it was found to be woefully inadequate, averaging only 4.5–10 tons/ha (Joosten et al., 2015). In this case, planting and managing banana plantations fell under the purview of smallholder farmers, the majority of whom were peasant women (Kabunga et al., 2012). Consequently, by 2016, banana exports made up around 32% of all fruit export revenue received from abroad (Directorate, 2016). One of the most often advised agricultural techniques is banana tissue culture, however adoption rates are just roughly 7% in Kenya and even lower in Uganda and Burundi (Warinda et al., 2020). Historical evidence from Kenya and other countries indicates that farmers may select one technical package element but ultimately reject or embrace a different one based on their assessments of risk and profitability (Mugo, 2013).

Like other cutting-edge technologies, the implementation of banana tissue culture technology has the benefits of expanding food access, generating revenue for the government through the sale of products, and creating jobs for women and young people (Banana Tissue Culture in India, 2019). However, what more has to be done to guarantee that future initiatives are more successful, and how far have researchers really progressed in arming small-scale farmers with the knowledge, resources, and instruments needed to participate in tissue culture banana cultivation (Woomer, 2012)? The inability to obtain timely and correct information has been identified as one of the primary barriers to Kenya's rural agriculture sector's expansion (Adolwa et al., 2010), consequently, tissue culture banana technology cannot be developed, especially considering how uneducated end users and households are. Additionally, there are gaps in the documentation of the types of data that smallholder farmers are in possession of (Obala, 2013). Wahome et al. (2021) noted that research needs to be financed in an effort to address these gaps given the limits in the knowledge, use, and exploitation of banana tissue culture techniques. These particular packaging adjustments may change the potential yield levels (Obaga and Mwaura, 2018). Conducting this research is essential to ascertain the farmers' awareness of the benefits of producing tissue-culture bananas and how that information affects the uptake and use of tissue-culture bananas. This will enhance the uptake of tissue culture bananas, boost their productivity, and lessen the incidence of food insecurity.

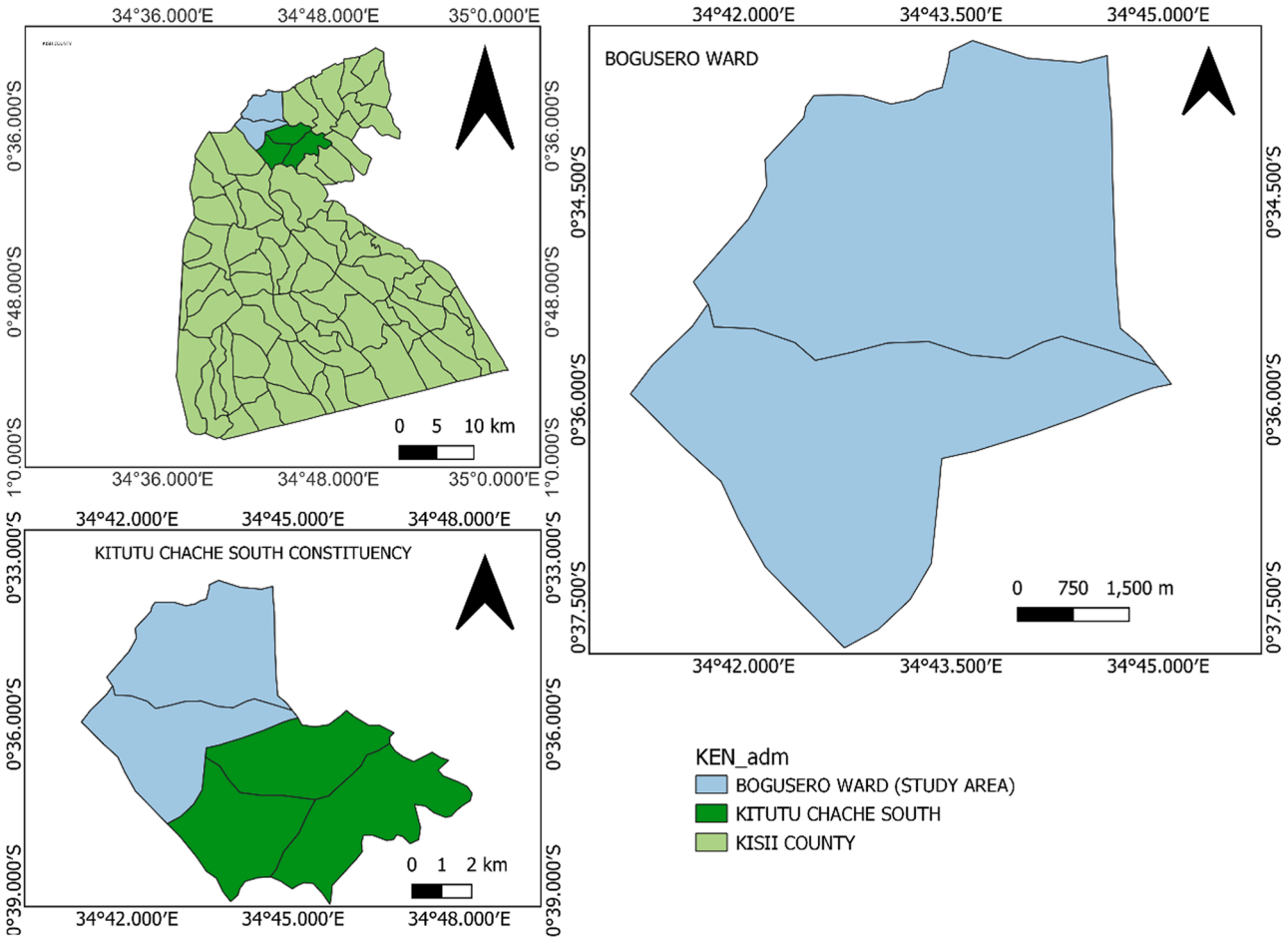

Fig. 1. Map of the study area. (Modified from Kenya administrative units).

Review of literature on the acceptance of tissue culture bananas

The agricultural sector has carried out a great deal of research on theoretical and practical strategies to encourage the adoption of innovative farming techniques (Kuehne et al., 2017). The adoption literature record makes an effort to categorize and arrange the factors affecting the adoption of agricultural techniques and technology (Kuehne et al., 2017). Theories about how decisions are made have traditionally emphasized extrinsic variables. They can be divided into three groups: characteristics of the farmer, features of the outside world, and characteristics of the innovation (Meijer et al., 2015). Numerous empirical research projects for the aquaculture sector (Amankwah et al., 2018) and a recent evaluation by Kumar (2017) found several factors impacting the uptake of agricultural technologies. Kumar (2017) acknowledged information source, technological features, financial factors, agricultural features, and institutional and sociodemographic factors.

It is challenging to implement a concept at the systemic or organizational level. Imposing modifications to standard practice becomes more challenging when organization decision-makers disagree that the changes are required (Garland et al., 2010). Even though private adoption is comparable. Aarons et al. (2011) found that while tackling challenges at the person level, organizational variables (such as hierarchy, culture, and values) are often absent, which makes it challenging to choose which innovation to embrace. It has also been observed that individuals who work for companies could have trouble understanding, evaluating, or selecting the right innovations to deal with specific problems. Talukder and Quazi (2011) found that people's acceptance of new ideas is significantly influenced by the attitudes held by members of their social networks about innovations. Moreover, research has shown that an individual's social network significantly influences how quickly they adopt new ideas.

Experts from a variety of professions and backgrounds have focused on the internal decision-making process that goes beyond the fundamental traits of farmers, environments, and technologies by incorporating psychological and motivational variables in technological uptake (McDonald et al., 2016). For instance, Davis (1989) introduced the Technology Adoption Model (TAM), a causal model that maintains that consumer acceptance and utilization of technologies are influenced by two important attitudinal components or beliefs: the technology's perceived usefulness (PU) and perceived usability (PEOU). Perceived utility of a technology, as opposed to perceived ease of use, which indicates the amount of work necessary to acquire and use the technology, indicates the benefits an individual feels technology can offer in terms of increasing their productivity at work (McDonald et al., 2016). McDonald et al. (2016) showed that an agricultural company will most likely be more profitable and acquire a competitive advantage if it adds greater value to the globe. Thus, it is essential to make sure that these factors are taken into account while utilizing tissue banana culture in a community. The farmer needs to know about tissue culture bananas in order to decide whether or not to accept the technique. When all of these things are taken into account, farmers are better able to use the technology because it influences their attitudes and views about tissue-cultured bananas, which influences whether or not they use the procedure to grow bananas.

Material and methods

Description of the study area

South-western Kisii County in Kenya is home to 1266,860 people and is situated in the Nyanza region (KNBS, 2019). The entire land area of the county is 1332.7km^2 and is located between 00° 30′ and 01° 0′ South Latitude and 34° 38′ to 35° 0′ East Longitude (GoK 2018). A portion of Kisii called Bogusero receives 1500 mm of rain a year, with the greatest showers occurring from March to June. The temperature swings from 15 °C to 20 °C at night and from 21 °C to 30 °C during the day (GoK 2018). Seventy-five percent of the ward is covered with red volcano soils, which are known for having a high organic content (GoK 2018). There are 24, 872 people living in the ward overall (KNBS 2019), a 32.70 km^2 land area, and sub-divided into Bigege and Raganga sub-locations, to make the southern location and Matieko and Santa sub-locations, to make the northern location. Fig. 1 shows the Bogusero ward in the Kitutu Chache South subcounty, which marks the northern boundary of Homabay County and Kisii County.

Table 1
Sample distribution.

Sub-location	Number of banana farmers	Sample size
Bigege	120	60
Raganga	90	45
Matieko	110	55
Santa	80	40

Research design

The study used a descriptive research methodology. Along with survey forms, interview schedules, and observation checklists, a well-designed and thoroughly validated questionnaire was used to gather data.

Questionnaire design

There were various sections in the questionnaire. The respondents were given a verbal explanation of informed consent throughout the first phase. The questionnaire was accurately completed once the respondents gave their approval along with an explanation and response for each item. In the section that follows, information regarding the benefits of employing tissue culture bananas was categorized using a five-Likert scale. The concluding section addressed the challenges faced by banana farmers in addition to some recommendations for enhancing tissue culture adoption.

Sampling procedure

The study employed simple random sampling to collect data from the respondents. An unequal sample size was randomly selected from each of the four nearly identical sub-locations that comprise Bogusero ward due to the farmers' uneven distribution, which made reliable statistics impossible to obtain. Since they are known to possess extensive knowledge of the agricultural systems in the research area, a purposeful sampling strategy was used to recruit all KARLO and Agricultural Officers at the ward level.

Sample size

Using the formula $n = N / [1 + Ne^2]$ from Yamane (1967), the sample size of 200 participants was decided. Where N is the target population, n is the sample size, e stands for the standard error, which is typically 0.05. $400/1 + 400 \times 0.05^2 = 200$ (Table 1).

Data analysis

Two-way mean comparisons were used to show the relationships between the adoption of tissue culture bananas and their benefits. The criteria below were used to determine each test item's level: Mode/median <3 high acceptance, mode/mean=3 moderate acceptance, mode/mean >3 low acceptance.

Table 2
Benefits of tissue culture banana among adopters and non-adopters.

Adoption	Benefits	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree	Total
Non-Adopters	Increased yield	1(0.5)	114(62.6)	51(28.0)	9(4.9)	7(3.8)	182(100.0)
	More income generating	2(1.1)	112(61.5)	52(28.6)	9(4.9)	7(3.8)	182(100.0)
	Pest and Disease resistant	4(2.2)	110(60.4)	52(28.6)	9(4.9)	7(3.8)	182(100.0)
	Short Growth period	1(0.5)	113(62.1)	51(28.0)	10(5.5)	7(3.8)	182(100.0)
	Promotes food security	1(0.5)	112(61.5)	52(28.6)	10(5.5)	7(3.8)	182(100.0)
Adopters	Increased yield	13(72.2)	5(27.8)	0(0)	0(0)	0(0)	18(100.0)
	More income generating	13(72.2)	5(27.8)	0(0)	0(0)	0(0)	18(100.0)
	Pest and Disease resistant	13(72.2)	5(27.8)	0(0)	0(0)	0(0)	18(100.0)
	Short Growth period	13(72.2)	5(27.8)	0(0)	0(0)	0(0)	18(100.0)
	Promotes food security	13(72.2)	5(27.8)	0(0)	0(0)	0(0)	18(100.0)

Values are frequencies followed by column percentages in parenthesis.

Results and discussion

Advantages of adopting tissue culture bananas

Advantages of adopting tissue culture bananas by respondents

The findings revealed that while 72.2 % of adopters strongly agreed that tissue culture banana technology increases overall banana yields, only 59.5 % of farmers overall and 62.6 % of non-adopters concurred (Table 2). The findings indicate that adopters were generally happy with the technology's ability to provide higher yields than non-adopters. Ten tons of fruit an acre is produced annually by tissue culture bananas, compared to five tons by native bananas, according to the study. Proponents of tissue culture bananas pointed to the crop's faster harvest, higher bunch weight, and uniform development and growth as reasons for the increased yields. They further claimed that because growth was uniform, farmers could more easily control field practices, enabling simultaneous harvesting to meet consumer demand. These results corroborated Nyang'au's (2019) observation that tissue culture farming produces higher yields.

The findings indicated that while 72.2% of adopters strongly believed that tissue culture bananas generate more money, only 58.5% of all respondents and 61.5% of non-adopters concurred. Therefore, we may conclude that farmers profit more from tissue-cultured bananas than from conventional bananas, according to the majority, noting that a higher percentage of adopters obtained this benefit (Table 2). They verified that whereas ordinary bananas cost between Ksh 300 and Ksh 800, a bunch of tissue culture bananas costs between Ksh 800 and Ksh 1600. Higher profitability has been associated with the crop's uniform and rapid growth, which allows for the simultaneous harvesting of numerous bunches of bananas. Additionally, banana bunches are larger and heavier than traditional ones, which did not mature uniformly. The marketing of sizable amounts of harvested bunches of tissue culture bananas allowed the farmer to enhance his income. These findings provide credence to the claim that the adoption of tissue culture bananas was significantly impacted by the percentage of income from banana sales, suggesting that farmers were incentivized to cultivate tissue culture bananas by the proceeds from banana sales (Wanyama et al., 2016). Consequently, when a household's percentage of banana profits rises, so does the adoption rate of tissue culture bananas. The fact that farmers were drawn to cash-generating agriculture ventures so they could pay their household expenses may help to explain this. Consequently, any efforts to boost household income from both agricultural and non-agricultural sources—such as credit—will spur the uptake of new technology, like tissue culture bananas.

The findings indicated that, with 57.5% of respondents, most people think that tissue-cultured bananas are a superior substitute in terms of resistance to pests and diseases. 60.4% of non-adopters agreed, while 72.2% of adopters strongly agreed, according to their responses (Table 2). Those who have adopted tissue-cultured bananas attested that, with proper care and field hygiene, particularly while planting, they are resistant to pests and diseases. According to small-scale farmers, the majority of farmers in the research region planted indigenous cultivars, which are susceptible to diseases that lower yields and cause large losses, which is the reason for the drop in banana output in the area. Weevils, worms, bacterial infections, and fungal illnesses have all been found to have an effect on banana production in the study region.

Table 3
Mean comparisons of tissue culture banana benefit items among small-scale farmers.

	Tissue culture banana adoption		
Benefits	Non-Adopters	Adopters	Total
Increased yield	2.49	1.28	2.38
More income generating	2.49	1.28	2.38
Pest and Disease resistant	2.48	1.28	2.37
Short Growth period	2.5	1.28	2.39
Promotes food security	2.51	1.28	2.39
Total	2.494	1.28	2.832

Mean <3 high acceptance, mean=3 moderate acceptance, mean >3 low acceptance.

The findings indicated that 72.2% of adopters strongly agreed that tissue culture bananas have a shorter maturity time, while 59% of respondents and 62.1 % of non-adopters concurred (Table 2). The findings demonstrated that tissue culture bananas develop swiftly and mature early because they have short stems and do not require stakes. In contrast, traditional suckers have lengthy stems that need to be anchored in order to keep them from breaking. Studies carried out by small-scale farmers who had adopted the method showed that tissue culture bananas bear fruit faster than regular bananas, taking only 300 days instead of the more than 400 days needed by conventional bananas. The results of this study are in line with those of Wambugu and Kiome (2001), who found that tissue culture plants develop more quickly and are therefore useful for farmers as cash crops.

The data showed that 72.2% of adopters and 61.5% of non-adopters strongly agreed that tissue culture bananas can support food security. Of all farmers, 58.5% agreed (Table 2). This was explained by the fact that bananas grown in tissue culture develop more quickly while also producing produce that is often of high quality and quantity, making it a quicker way for people inside and beyond the study region to get food. This demonstrates that the majority of respondents knew that food security is supported by tissue-cultured bananas.

The influence of the advantages of tissue culture bananas adoption on tissue culture banana adoption

The mean of 2.832 demonstrated strong acceptance of the benefits accruing from tissue culture banana use, indicating that all banana farmers in the region generally acknowledged that the use of this technique yields several benefits. All of the factors examined under the benefits of employing banana tissue culture were found to have a significant impact on the adoption of tissue culture banana engineering when subjected to mean comparison tests (Table 3).

Those who did not adopt had an average mean of 2.494, whereas

those who did adopt had an average mean of 1.28. This shows that farmers in Kisii County who had embraced tissue culture banana technology had an advantage over non-adopters in terms of the benefits received from tissue culture banana production, which is why they strongly supported the technology's continued acceptance. The simplicity of testing new innovations to verify their benefits increases farmers' inclination and speed of adoption; this may rely on how quickly the innovations can be tested for little or no cost (Yigezu et al., 2018).

Conclusion

It has been determined that farmers' awareness of the benefits of the technique has a major role in the uptake of tissue culture bananas. It was observed that non-adopters of the technology had somewhat lower levels of technological knowledge of advantages, which resulted in low adoption, in contrast to adopters, who were found to have high levels of technological knowledge of advantages, which led to high adoption. It's easy to use and maintain for farmers who are experienced with tissue culture techniques. Therefore, in order to bridge the knowledge gap and boost technological adoption, it is imperative that suitable tissue culture banana production techniques be continuously pushed. Numerous settings, including community-based group teaching and demonstration, are suitable for this.

CRediT authorship contribution statement

Erick Nyaboga Omari: Resources, Writing – original draft, Writing – review & editing. **Monicah Mucheru-Muna:** Supervision. **Benson Kamau Mburu:** Supervision. **Abdiwali Abdulle Odawa:** Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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